Volume Title
ASP Conference Series, Vol. **Volume Number**
Author

Modeling the Asymmetric Wind of Massive LBV Binary MWC 314

A. Lobel[1], J. Groh[2], K. Torres Dozinel[3], N. Gorlova[4] , C. Martayan[5], G. Raskin[4], H. Van Winckel[4], S. Prins[4], W. Pessemier[4], C. Waelkens[4], Y. Frémat[1], H. Hensberge[1], L. Dummortier[1], A. Jorissen[6], S. Van Eck[6], and H. Lehmann[7]

[1]*Royal Observatory of Belgium, Ringlaan 3, B-1180 Brussels, Belgium*

[2]*MPI for Radioastronomy, Auf dem Hügel 69, D-53121 Bonn, Germany*

[3]*University of São João Del Rei, CAP, 36420-000 Ouro Branco, MG, Brazil*

[4]*University of Leuven, IvS, Celestijnenlaan 200 D, B-3001 Heverlee, Belgium*

[5]*ESO, Alonso de Cordova 3107, Vitacura, Santiago, Chile*

[6]*Université Libre de Bruxelles, Blvd. du Triomphe, B-1050, Brussels, Belgium*

[7]*Thüringer Landessternwarte, Sternwarte 5, D-07778 Tautenburg, Germany*

Abstract. Spectroscopic monitoring with Mercator-HERMES over the past two years reveals that MWC 314 is a massive binary system composed of an early B-type primary LBV star and a less-luminous supergiant companion. We determine an orbital period P_{orb} of 60.85 d from optical S II and Ne I absorption lines observed in this single-lined spectroscopic binary. We find an orbital eccentricity of e=0.26, and a large amplitude of the radial velocity curve of 80.6 km s^{-1}. The ASAS V light-curve during our spectroscopic monitoring reveals two brightness minima ($\Delta V \simeq 0^{m}.1$) over the orbital period due to partial eclipses at an orbital inclination angle of $\sim 70°$. We find a clear correlation between the orbital phases and the detailed shapes of optical and near-IR P Cygni-type line profiles of He I, Si II, and double- or triple-peaked stationary cores of prominent Fe II emission lines. A preliminary 3-D radiative transfer model computed with Wind3D shows that the periodic P Cygni line profile variability results from an asymmetric common-envelope wind with enhanced density (or line opacity) in the vicinity of the LBV primary. The variable orientation of the inner LBV wind region due to the orbital motion produces variable P Cygni line profiles (with wind velocities of $\sim$200 km s^{-1}) between orbital phases ϕ = 0.65 to 0.85, while weak inverse P Cygni profiles are observed half an orbital period later around ϕ = 0.15 to 0.35. We do not observe optical or near-IR He II, C III, and Si III lines, signaling that the LBV's spectral type is later than B0. Detailed modeling of the asymmetrical wind properties of massive binary MWC 314 provides important new physical information about the most luminous hot (binary) stars such as η Carinae.

1. Introduction

MWC 314 (V1492 Aql; BD+14°3887; V=9^{m}.9) is a candidate Luminous Blue Variable (LBV) previously proposed to be one of the most luminous stars of the Galaxy by Miroshnichenko et al. (1998) with $\log(L_\star/L_\odot)\simeq 6.1\pm 0.3$, $T_{\rm eff}\simeq 25$ to 30 kK, and $\dot{M}\sim 3\,10^{-5}$ M$_\odot$ yr^{-1}. More recently, Muratorio et al. (2008) found that the star is a binary

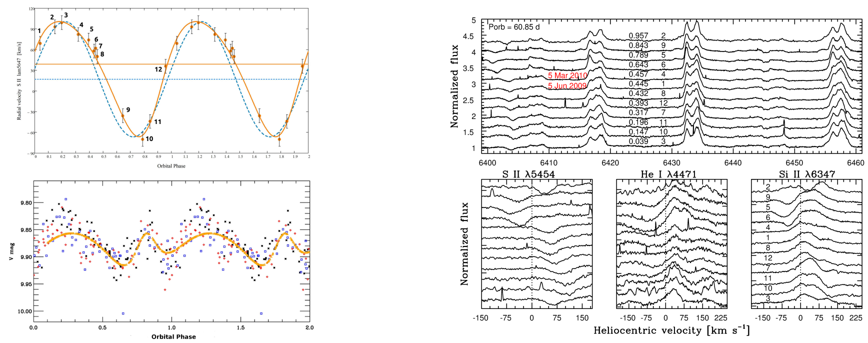

Figure 1. *V*- and radial velocity-curve of MWC 314 from high-res. spectra (*see text*.)

system with an orbital period of ~30 d using optical spectra, however without determining other orbital parameters. We therefore observed 12 high-resolution spectra over the past two years with Mercator-HERMES (R=80,000) at La Palma (Spain). HERMES is a high-efficiency échelle spectrograph covering 420 nm to 900 nm (Raskin et al. 2011). We observed the spectra of MWC 314 with large SNR~100 for accurate radial velocity (RV) measurements and detailed line profile studies. On 5 & 9 Sep 2009, and on 17 & 20 Mar 2011 we also observed two spectra within 5 d to investigate possible short-time spectroscopic variability in MWC 314 (see also Lobel et al. 2011).

2. Radial Velocity and Visual Brightness Curves

The upper left-hand panel of Fig. 1 shows RV measurements of the S II λ5454 absorption line in the lower middle panel. We find a best fit (*orange solid curve*) for an orbital period $P_{\rm orb}$=60.85 d, e=0.26, and systemic (center-of-mass) velocity of +38.8 km s^{-1}. The amplitude of the RV-curve is large 80.6 km s^{-1}, and is skewed (compare with the blue sine curve) due to the eccentricity of the LBV orbit. The lower left-hand panel shows the V-curve observed by ASAS-3 in 2002-2009 (Pojmanski 2002). The red, blue, & black dots show 3 epochs of ~10 $P_{\rm orb}$ folded for one $P_{\rm orb}$. The mean V-curve (*orange dotted curve*) reveals two unequal brightness minima due to partial eclipses around periastron ($\phi\simeq$0; the LBV is then in front of the companion) and apastron passage ($\phi\simeq$0.6). The RV- and V-curves signal a less-luminous massive (supergiant) companion star. The shapes of spectral lines in the upper right-hand panel of Fig. 1 very regularly vary over $P_{\rm orb}$. Small flux changes in the double-peaked Fe II emission lines (*upper panel*) almost exactly repeat over time (compare spectrum Nos. 1 and 4), revealing that the optical spectrum variability chiefly results from the LBV orbital motion.

3. 3-D Radiative Transfer Wind Modeling with Wind3D

The 12 orbital phase positions of the LBV are shown (*solid red dots*) with respect to the companion star in the left-hand panel of Fig. 2. Strong P Cyg wind profiles are observed for ϕ=0.65 to 0.85 in He I λ4471 and Si II λ6347. We compute with the WIND3D code that the P Cyg profiles are properly explained with a model of larger wind density surrounding the LBV (*shaded small sphere in the middle panel*) inside a

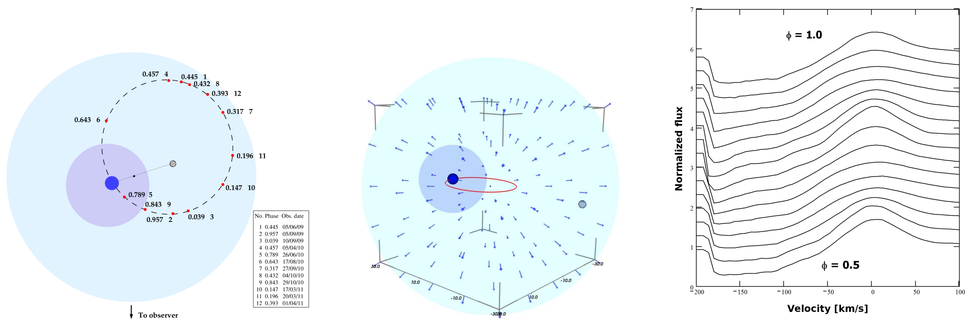

Figure 2. Observed orbital phases and 3-D wind model for MWC 314 (*see text*).

circumbinary wind envelope (expanding around the center-of-mass velocity). The latter wind envelope causes the static emission lines, while the blue-shifted wind absorption becomes most noticeable (i.e., He I computed in the right-hand panel of Fig. 2) with respect to the line emission when the LBV fastest approaches the observer.

4. Conclusions

Based on long-term spectroscopic monitoring with Mercator-HERMES we confirm the binarity of candidate LBV MWC 314, first conjectured by Muratorio et al. in 2008. However, we determine an orbital period of 60.85 d (twice longer than $P_{\rm orb}\sim$1 m they proposed) from an accurate solution of the RV-curve. We also compute an orbital eccentricity of 0.26 with LBV periastron passage oriented almost towards the observer. The visual brightness curve reveals two unequal minima signaling partial eclipses at an orbital inclination angle of $\sim$70° in the plane of the sky. We also confirm the LBV character of MWC 314 with strong P Cygni-type line profiles observed during the orbital phases of fastest approach around periastron passage. A 3-D radiative transfer model we compute for the wind of MWC 314 shows that the P Cyg profiles result from enhanced LBV wind density inside a circumbinary expanding wind envelope.

Acknowledgments. A.L. acknowledges funding from the ESA/Belgian Federal Science Policy in the framework of the PRODEX programme. The HERMES project and team acknowledge support from the Fund for Scientific Research of Flanders (FWO), Belgium, support from the Research Council of K.U.Leuven (Belgium), support from the Fonds National Recherches Scientific, Belgium (FNRS), from the Royal Observatory of Belgium and from the Landessternwarte Tautenburg (Germany).

References

Lobel, A., Groh, J.H., Torres, K., & Gorlova, N. 2011, Proceedings IAU Symposium No. 272, eds. C. Neiner, G. Wade, G. Meynet & G. Peters, 519

Miroshnichenko, A. S., Frémat, Y., Houziaux, L., Andrillat, Y. et al. 1998, A&AS, 131, 469

Muratorio, G., Rossi, C. & Friedjung, M. 2008, A&A, 487, 637

Pojmanski, G. 2002, Acta Astronomica, 52, 397

Raskin, G., Van Winckel, H., Hensberge, H., Jorissen, A., Lehmann, H., Waelkens, C., et al. 2011 A&A, 526, A69